Summary of Response Options for Oil Spill Cleanup in Wetlands

1. Executive Summary and Recommendations

The State's booming and pass closure response plan to the Deepwater Horizon incident focused on limiting the intrusion of spilled oil into the wetlands of south Louisiana. It has become clear that despite coordinated attempts the fringes of the south Louisiana wetland complex and fragmented islands of marsh cannot reasonably be protected and will likely be subjected to oiling. Consideration of the options available to clean wetlands is thus necessary. In addition, those response considerations must be extended to interior wetlands, based on the assumption that at some place or some point the multiple boom lines will eventually fail to hold back the oil.

This section discusses intrusive and non-intrusive response options, separated by the need of response personnel to physically enter and actively transit, either by foot or via mechanical treatment, through the oiled wetlands. Although the Incident Command should maintain a toolbox with all available response options, and evaluate under what conditions certain responses are more appropriate, ***OCPR recommends that in general intrusive response options be avoided***, as even light foot traffic from response personnel activities can cause significant and long-lasting harm to the integrity of the soft soils underlying Louisiana's wetlands. However, it may be necessary to utilize these methods on a case by case basis to protect proximate wildlife and critical habitat or to remove large quantities of collected oil. The preferred response options from this class are

- Gentle flushing (2.2.4) coupled with sorbent mops/mats (2.2.1) and Airboat-Deployed Vacuum Recovery (ADVR, 2.2.5) and
- Phytoremediation via Transplantation (2.2.3).

A number of non-intrusive response options pose less of a physical threat to wetland soil integrity. Of these, dispersant use in aquatic systems is controversial but potentially viable, as outlined in 2.3.4 below. ***The three preferred non-intrusive response options are***

- Natural Attenuation (2.3.5).
- Bioremediation: Bioaugmentation and/or Biostimulation (2.3.1),
- In-situ burning (2.3.2), and

In areas where marsh recovery is impacted by flooding frequency, sediment addition may need to be coupled with various response methods.

The advantages and concerns associated with these response options are outlined in this document, and help frame a strategy to help remediate anticipated impacts of the Deepwater Horizon spill on coastal Louisiana wetlands. These strategies build on similar guidelines identified by NOAA.

Given the timing of the Deepwater Horizon oil spill, a three step approach coordinated with seasons is appropriate. (1) Initially during the spring with the higher water levels and recent sprouting of vegetation, gentle flushing of wetlands (pumped water and mild cleaners) and containment in adjacent open waters along with sorbent mat/mop cleaning along boat accessible shorelines would be appropriate to remove oil from the vegetation while minimizing disturbance to the soil surface. (2) Less intrusive options (natural attenuation; bioremediation) should be employed throughout the bulk of the vegetative growing season (late spring through early fall) as lower water levels and increased temperatures allow the microbes and plants to biodegrade the remaining oil. (3) After assessing oil levels at the end of the growing season (not only what is remaining since the beginning of the oil spill, but also what new oil has been spilled until closure of the well site), options such as in-situ burning (mid autumn to mid winter) and transplantation of vegetation (mid winter to early spring) should be considered on a site-by-site basis.

2. Supporting Information

2.1.Overall Considerations

2.1.1. Type of oil

The nature of the oil to which the wetland is exposed is a critical consideration for determining the best option for cleanup. Lighter and/or refined hydrocarbon products such as gasolines or gas condensate products are more toxic to the affected ecosystem, all else being equal, compared to crude oils and weathered products which pose more of a physical stress from coating and smothering. Products with greater diversities of hydrocarbon components, especially those weighted towards the lighter-end products (e.g. light straight-chain aliphatics and polycyclic aromatic hydrocarbons, or PAHs) also tend to be more susceptible to biological and chemical degradation and burn more readily (Pezeshki et al 2000). In comparison, heavily-weathered products are not as easily degraded or burned, and are better candidates for natural attenuation. Analyses are still pending on the detailed chemical nature of the Deepwater Horizon spilled oil, especially regarding changes to the oil that are occurring as it enters the Louisiana coastal nearshore environment. Results of those analyses will greatly inform the wetland response decision-making process.

2.1.2. Type of wetland

NOAA ranks sheltered tidal flats and marshes as two of the most sensitive community types to oil spills. Given the predominance of wetlands and tidal flats in the State's coastal zone, the Louisiana coastline is one of the most sensitive areas in the country to an oil spill of this magnitude. Wetland community sensitivities to crude oil are largely influenced by the underlying soil type, and specifically, the organic versus mineral content of the soil. Organic soils have more surface area than mineral soils (allowing the oil to "stick" more firmly) and are much softer and are heavily impacted by any intrusive method.

In coastal Louisiana, herbaceous wetlands (marshes) are likely to be the most impacted by the oil spill as they dominate the coastal zone. Salt marshes may be more resilient to any effects of the spill owing to tidally-driven natural flushing and the relatively high mineral content in the soils. Brackish marshes have less tidal influence and are typically more organic than salt marshes, possessing a more anaerobic soil environment and finer grained organic soils. The intermediate marshes are characterized by soft, organic soils that cannot sustain any amount of foot traffic, seriously limiting response options. Tidal freshwater marshes are arguably some of the most sensitive areas that could be impacted due to their low input of sediment, high subsidence levels and fragile, organic soils. Traffic, personnel or equipment, in any of these areas would be extremely detrimental to marsh integrity and limit their capacity for recovery post spill (LA DEQ et al 2007).

Forested and shrub/scrub wetlands in Louisiana include freshwater swamps, bottomland hardwood forests and mangrove swamps. It is inappropriate to do any cutting or burning in these areas, but the community should be able to withstand low pressure flushing or sorbent pad application should it be deemed necessary. Given optimal flooding conditions and low toxicity levels, these areas should be able to re-vegetate by natural colonization.

In summary, the less tidal influence and the more organic the soil, the more difficult it is to remove the oil. Clean-up options for this oil spill must take into account the type of wetland environment they are being mobilized in. The method used will depend on the individual wetland vegetation and soil type, temperature, oxygen content, nutrient availability, pH, salinity and flooding frequency (Venosa & Zhu 2003).

2.1.3. Water level on wetland

The effects of oil spills and the effectiveness of oil spill response options on coastal wetlands differ throughout the year, and basically follow the growing season and senescence of the vegetation as affected by photoperiod, temperature, and water levels as well as daily tidal input. Water level in the marsh is critically important at three distinct points during a spill incident; 1) the time of wetland exposure, 2) the time of the cleanup response, and 3) post clean-up.

At the time of exposure if water levels are low soils are more likely to be covered and it is imperative that no traffic be allowed at the area, as this could push the oils down into the sediment. If water levels are high at this time it is more likely that plant leaves will become coated and plant mortality is likely (Hester & Mendelssohn 2000). Additionally, high water levels will possibly result in oil that is more mobile to surrounding areas and a rapid clean-up option may be desirable to prevent further contamination. Under low tidal amplitudes such as those in coastal Louisiana, the water level may not be high enough to fully coat leaf surfaces and will be less lethal to plant life and those marshes will be more likely to persist if the oils are moderately non-toxic.

At time of clean-up the water level will heavily influence the response option chosen. For example, if water levels are low neither in-situ burning nor flushing would be an available option and any airboat traffic could severely damage the physical soil structure. If water levels are high at times of clean-up it will be possible to in-situ burn, flush and/or use airboats in that area. The flooding frequency of the wetland impacted will affect post clean-up marsh recovery; wetlands with anaerobic conditions (low tidal influence, freshwater) will likely take longer to degrade the oil naturally than areas that are subject to natural tidal flushing mechanisms that provide oxygen for biological activity. In some studies, contaminated marshes required sediment addition (an increase in elevation to decrease in flooding frequency) to re-vegetate successfully (Dowty et al 2001; Hester & Mendelssohn 2000; Michel et al 2009; Venosa et al 2002).

2.2.Intrusive Response Options

2.2.1. Sorbent mats

Background:

Historically one of the most common cleanup responses to oiled wetlands was to have a team of spill responders traverse the spill site carrying sorbent mats, or pom-poms, and physically place them on oiled wetland soils or into collected pools to sop up the spilled product. The primary advantage of this response measure is that it allows for targeted cleanup of spilled material that can protect sensitive wildlife and critical habitat areas from exposure.

The concerns with this response option are significant and typically results in substantial physical disruption to the integrity of wetland soils. Damage to wetland soil structure delays ecosystem recovery and is likely to exceed any damage imposed by the spilled oil and hasten marsh breakup to open water. There are also problematic disposal issues with the oiled sorbent mats after clean-up that can pose considerable logistical constraints on the use of this option, especially when combined with the need to transport large numbers of response personnel to the spill site.

Sorbent maps/pom-poms are effective when used on shorelines accessible by boats (canals, steams, cut banks) and along boundaries of other oil collection options such as open water skimming or gentle wetland flushing. Given the high probability of significant damage to marsh soil integrity from response personnel activities and the logistical challenges described above, sorbent pads should only be used by personnel working from airboats or small john-boats when there is enough water on the marsh surface so that the boats float and do not touch the marsh surface. If this is not feasible, this cleanup approach is not recommended as a response option

Recommendations:

- Recommended when personnel and associated equipment (boats) can stay off marsh surface or in forested wetland areas
- Recommended to protect critical (fish and wildlife) habitat areas from exposure
- Most effective immediately following contamination with oil for rapid recovery

2.2.2. Cutting of Oiled Vegetation

Background:

Vegetation cutting may protect sensitive wildlife associated with marshes or enhance the recovery of oily vegetation. Positive effects of marsh cutting on vegetation recovery were almost always seen where a heavy fuel oil or a heavy crude oil was spilled versus light oil. Cutting in the fall or winter (when plants are dormant) resulted in better recovery than cutting plants during their growing season. Physical damage to root systems and changes in geomorphology and hydrology due to response personnel foot traffic dramatically reduce the ability of a marsh to re-vegetate after cutting, particularly in soft, muddy soils (Zengel & Michel 1996). Additionally, if there is still floating oil proximate the removal of vegetation can actually allow deeper penetration of oil into the wetland (Challenger et al 2008).

Recommendations:

- Only recommended in areas of high ground and where foot traffic is minimized
- Only recommended when oil is no longer mobile and is fixed to vegetation
- Not for use in forested wetland types, only marshes
- Not recommended during growing season
- Useful to protect sensitive wildlife associated with marshes

2.2.3. Phytoremediation via Transplantation

Background:

With this technique, live plants and associated soil are transplanted from a nearby healthy donor marsh into the impacted wetland. Following and oil spill seed germination and vegetative growth can be slowed significantly or temporarily halted. Transplants have the potential to enhance the degradation of hydrocarbons in the soil by aerating the root zone and feeding soil bacteria with photosynthates, thus stimulating aerobic bacterial degradation of the hydrocarbons, particularly in organic, freshwater marshes (Holm et al 2003).

The primary concern in transplanting is that the amount of response personnel traveling through the impacted wetland can seriously threaten marsh soil stability. In addition, its widespread use is limited in larger impact areas by the expense and effort needed to obtain and plant enough vegetation to benefit the site root zone. Success may be limited in these systems when the oil is fresh and poses a toxicological threat to the transplanted vegetation and personnel onsite. In some field tests the ability for transplants used for phytoremediation was closely related to marsh elevation and could potentially require sediment additions in sites with a high flooding frequency (Hester & Mendelssohn 2000). Transplanting vegetation should thus be limited to small sites with firm soils, where the spill is characterized by highly-weathered or otherwise low toxicity product. Careful selection of species will be necessary; all species considered for phytoremediation should be native and represent the healthiest genotype for restoration purposes (Smith & Proffitt 1999).

Recommendations:

- Only recommended for small areas with firm soils where the spill is characterized by a highly weathered and/or low toxicity oil
- Not for large scale use
- Should be timed after the growing season (late winter through mid spring)
- Use only native wetland plants

2.2.4. <u>Low-pressure / High-pressure Flushing</u>

Background:

Flushing involves a variety of washing or flushing methods (i.e., high and low pressure, heated or unheated water), that are used to move oil from the shoreline to a location for collection from where it can be collected for disposal. Along beaches and highly mineral shorelines oil may be flushed from beaches or shorelines with hoses attached to conventional vessels or barges that have been outfitted to pump water. A site can be flushed with ambient seawater to float oil off or out of sand or sediments and into a collection area. The remobilized oil can then be trapped by booms and subsequently removed by skimmers, sorbents or other suitable methods. Within a flooded wetland with securely rooted vegetation, a gentle flushing of water, and maybe mild cleaners, could be used to remove oil from the vegetation and marsh. Uncontaminated water should be gently flushed through the marsh towards and open water area accessible to equipment used to collect the oil; the pressure should be low enough to not gouge the marsh surface.

Flushing methods are much more common and much less disruptive to soil integrity on sandy shorelines such as barrier islands and beaches. If done carefully, flushing could be used to remove floating oil in areas dominated by woody vegetation, securely rooted emergent marsh and thick-mat, floating marsh. Interior marshes without a large water body to push the oil into will need the addition of airboats for collection and increase oil penetration into the soil surface (Lin et al 1999). Gentle flushing of vegetated wetlands should only be conducted when the soil surface is already flooded to provide protection from scour, because even gentle (low pressure) flushing would likely disrupt the integrity of the exposed soils to such a degree that any benefit would be negligible compared to the detriment of the soil surface elevation loss as a result of scour. A major limitation to this option in large-scale oil spills is the availability of uncontaminated water.

Recommendations:

- Only recommended in very sandy soils (beaches) and flooded wetlands with securely rooted vegetation
- Not for use in areas with soft, organic soil that is exposed
- Useful for rapid recovery to protect sensitive areas or wildlife
- May require coupling with airboat recovery and or sorbent maps/mops
- Useful to protect sensitive wildlife associated with marshes

2.2.5. <u>Airboat-deployed Vacuum Recovery Systems</u>

Background:

The use of vacuum recovery systems mounted onto airboats has to date only been used once in 2007. Bayou Perot delicate tidal flats had been at low water level at time of exposure to sticky, non-toxic oil. After trial and error it was determined that the only method that could effectively remove oil without causing unacceptable damage to the mud flats was to mount small vacuums onto airboats and squeegee the oil into piles manually for vacuum removal (Henry et al 2008). In practice, this could be a valuable tool to clean impacted un-vegetated tidal flats any oiling. As the construction of large airboats is a newly expanding business, the absence of a large fleet of converted vessels limits the AVRS option to small areas. This option may be better suited as a support role to other efforts such as flushing in areas not accessible to larger equipment.

This method will not be applicable in enclosed marshes and could be very labor intensive and expensive, but could be beneficial if fragile mud flats are impacted. In wetlands, this option would be limited to oil removal from the water surface over a greatly flooded marsh. Marsh soils would be harmed and removed if the vacuum was deployed beneath the surface of the water.

Recommendations:

- Only recommended for small patches of oiled tidal mud flats and highly flooded wetlands
- Not for use in any other wetland type
- Useful for rapid recovery to protect sensitive areas or wildlife

2.3. Non-intrusive Response Options

2.3.1. Bioremediation: Bioaugmentation and Biostimulation *(Holm et al)*

Background:

Vegetation and soil microbial communities are interlinked in wetland ecosystems; they provide each other with the energy and supplements needed for physiological function (metabolism) and production which are necessary to break down oil, a process known as bioremediation or biodegradation. Although toxic for plants to absorb through their roots, hydrocarbons are a food source for many microbial communities. The rates at which microbial communities can remediate an oiled area will depend on the type of oil impacting the area as well as a suite of environmental factors such as temperature, soil aeration (oxygen), salinity, pH and available nutrients (Venosa & Zhu 2003). For the most efficient (and fastest) consumption and processing of hydrocarbons, bacteria use oxygen as an energy source which is respired into the soil through the roots of plants; other energy sources, such as sulfates, are useful but do not lead to the most efficient metabolism. Nutrients needed for plants metabolism and production are made available in the soil by bacteria as they consume the hydrocarbons. Enhancements to this relationship via bioremediation (bioaugmentation / biostimulation) during periods of stress may aid in eventual oil removal.

Bioaugmentation is the addition of bacteria and other microbes into the affected area to boost natural processes and consume harmful hydrocarbons resultant from the spill. This tactic would only be necessary if the spill were toxic enough to kill all indigenous populations of the microbial community. Some companies are marketing the addition of oil degrading bacteria but this is not a mainstream or well tested theory. Naturally occurring bacteria populations that consume hydrocarbons usually increase following a spill (to compensate for the killed populations) and outcompete any introduced non-native bacterial species. The application of fungi has been suggested because of its contribution to soil oxygenation but research is similarly vague on the actual benefits of their addition into an area.

Biostimulation refers to the addition of limiting nutrients (fertilization) into a degraded soil to stimulate the activity of naturally occurring microbes and/or stimulate plant growth, which can secondarily enhance degradation of oil in the root zone. There is some disagreement in the scientific community as to the benefit of fertilization but studies have shown that additions of nitrogen and, in saturated environments, sulfate have the potential to expedite the degradation of petroleum hydrocarbons.

Both biostimulation and bioaugmentation have the advantage of being very passive and do not impact the physical marsh habitat in a negative way. The addition of limiting nutrients, supplementary bacteria and/or fungi could potentially re-mobilize nutrients to the surviving plants and assist in oxygenating the sub-soil, encouraging natural biological degradation of the oil. In the presence of native microbial communities, further addition of bacteria may not be necessary given the presence of native microbial and fungal communities and their ability to bioremediate naturally. There has been some indication that crude oil may temporarily stimulate vegetative growth in fresh marshes by removing bacteria predators and making way for oil resistant bacterial populations to flourish (Nyman 1999). The contribution of fertilizer application to coastal eutrophication and hypoxia is a great concern and must be given careful attention and consideration. In addition, nitrogen fertilization can cause a shift in the biomass allocation of marsh plants, redistributing below ground to above ground biomass and ultimately reducing soil stability.

Although the empirical evidence promoting either bioaugmentation or biostimulation in oiled wetlands is limited, the available data warrants further pursuit of this technology. It could be valuable to apply either of these response options to oiled wetlands where conditions allow, especially as an alternative to either in-situ burning or natural attenuation, coupling response application with research funds to further evaluate the response of the oiled community. If this option is used it will be useful to first determine the limiting nutrient in the soil community; oxygen, nitrogen or sulfate to ensure maximum benefits and limit further eutrophication (Venosa & Zhu 2003).

Recommendations:

- Recommended as augmentation on a case by case basis, carefully considering the chemistry of the oil and wetland type to determine cost (eutrophication and/or hypoxia) and benefits (increased degradation of oil)
- Appropriate for use in interior wetlands with little tidal flushing
- Use as an opportunity to couple with research funds to evaluate response
- May be useful in areas where other methods (intrusive) are not possible

2.3.2. In-situ Burning

Background:

In-situ burning refers to the burning in place of oil spilled in the wetland and is typically used to remove oil that cannot be recovered by alternative means (Fritz 2003) In the case of a spilled product with a large content of lighter-end components, ignition can sometimes be direct. In the case of more complex or weathered products, accelerants can be used to achieve initial ignition of the spilled oil.

In-situ burning offers a number of advantages as a response option. In areas where there is a time sensitive need to remove oil from a habitat, such as an upcoming change in physical conditions of the wetland that could result in spreading (like a flood) or a seasonal increase in wildlife use (migratory waterfowl), burning can rapidly remove remaining oil (RRT 1996). It reduces the need for response personnel to enter the oiled wetland during clean-up and limits the physical damage done to the marsh soil structure and promoting a more vigorous recovery of the vegetation. Further, many of the coastal wetlands of the Gulf Coast are fire adapted ecosystems where frequent burning is a natural occurrence, or was historically. In these areas, in-situ burning may actually stimulate natural processes which have been prevented due to fire suppression.

The hydrologic regime of a wetland is a critical consideration; an adequate layer of water must exist on the surface of the wetland at the time of the burn to ensure plant recovery (Lin et al 2002). The water layer absorbs much of the heat of the fire; without this layer, significant heat transfer from the fire into the marsh soil and into plant roots can occur, which will kill the plants and prevent post-burn emergence of new plant stems. Burning experiments demonstrated that *Spartina alterniflora* recovery post spill was almost completely inhibited if the water table was 10cm below the soil surface (Lin et al 2002). But in similar studies where the water table was higher in-situ burning provided valuable oil removal services and did not impact the recovery of *S. alterniflora* (Lindau et al, 1999). Similar results were found in freshwater wetland in-situ burns (Fritz, 2003). A standing water layer overtop the marsh soil also prevents the generation of peat fires. However, after the burn excessive water levels over the marsh can drown plant roots in the absence of plant stems emerging through the water, as described above for vegetative cutting as a response mechanism. In areas where there is floating oil present and any less intrusive cleanup option is not possible, in situ burning of the marsh may be the best option as leaves are very sensitive to the continued presence of oil (Lin et al 1999).

In-situ burning is neither applicable to all spills in all systems or without potential negative consequences. Burning is not a viable option for forested wetlands, such as swamps, or scrub-shrub communities. Although appropriate for herbaceous wetlands where the plants typically contain adequate belowground reserves that can be re-allocated and drive subsequent re-growth, woody wetland plants typically do not recover from fires, and an in-situ burn in these wetlands will result in long-term damage to the ecosystem. Burning should also be avoided in the summer and early fall, when belowground resources are insufficient to provide nutrients which facilitate the growth of new stems.

Of concern is the possibility that burning may change the chemical makeup of the oil and can lead to an increase in more toxic hydrocarbon species such as smaller, lighter aliphatics as well as polycyclic aromatic hydrocarbons (PAHs). This could potentially to lead to mobilization of surface hydrocarbons into and through the underlying soil profile, which can expose plant rhizomes and roots to toxic hydrocarbon species. Burning of complex hydrocarbon mixes, such as that found in crude oil, typically leaves behind the heavier asphaltic components of the crude. If thick enough, this residue can impede post-burn emergence of new plant stems and thus serve as a long-term stress to ecosystem recovery.

Lastly, there are pollution, social and permitting issues associated with in-situ burning. Depending on the nature of the oil and size of the area impacted, burning may pose a potential air quality problem and will at minimum require a permit from the parish and the Department of Environmental Quality. In the case that the smoke released is not toxic aesthetic concerns arise if the smoke plume is transported over human habitation. Burning should be avoided in proximity to populated areas for this reason.

Recommendations:

- Only recommended in grass dominated marsh areas with adequate water table (at least 3-4 inches) after the growing season (mid fall to mid winter)
- Not appropriate in any other wetland type
- Avoid in populated areas
- Useful for rapid recovery to protect remobilization to sensitive areas
- Useful to prevent contamination of immigrating wildlife

2.3.3. Dispersants/Cleaners

Background:

The use of dispersants to break up spilled oil into smaller particles that are more easily biodegraded is a critical response path to the spill while it is in open water. This is the acceleration of a natural process that makes more surface area of the oil particles available for microbial activity (BTNEP 2010). Cleaners may be similarly helpful for removing large amounts of oil coverage along fringing wetlands when used in coordination with oil removal efforts from the water. Cleaners may also be useful to remove oil adhering to woody plant stems, especially for species with respiratory (gas exchange) mechanisms near the average water level.

It is important to note that dispersants do not actually get rid of any oil and their use on discrete, highly-contaminated areas risks exposing a larger areas, adjacent wetlands and/or water bodies to lower concentrations of the same oil. In fact, smaller particles more readily penetrate into wetland soil where it degrades slower compared to remaining on the surface. Although studies show that the dominant vegetation in Louisiana's wetlands has some tolerance to dispersants there is typically an associated and widespread toxicity to aquatic and marine micro and macro-invertebrates. In some cases the use of dispersants in Gulf wetlands significantly decreased post spill re-vegetation in *S. alterniflora* salt marshes (Pezeshki et al 2000). Further, it has been suggested that dispersants may only be useful to disperse oil in areas where biotic (bioremediation) or abiotic (physical tidal flushing) mechanisms are not adequate to disperse oil by natural means (Page et al 2001).

Evidence suggests that the use of dispersants inshore and on oiled wetlands should be avoided. However, the use of dispersants could be rationalized to rapidly remove oil from a forested wetland that is at risk from a more toxic product. Trade-offs between potential harm to the faunal community versus toxicity-induced losses to the vegetation is a crucial consideration (Kirby & Law 2008).

Recommendations:

- Not recommended in general
- Could be used in site specific cases to protect sensitive areas proximal to concentrated oil
- Not recommended in areas with sensitive wildlife communities
- Support the use of the least biologically harmful/toxic type of dispersant/cleaner if deemed necessary

2.3.4. Natural Attenuation

Background:

Perhaps less intuitive but certainly as important a consideration is the option of taking no corrective actions to clean the oil-impacted wetland, and allowing on natural processes to attenuate and degrade the spilled oil over time. Although recovery of the ecosystem and removal of the spilled oil is slower via natural attenuation, it does prevent the physical damage to marsh soil structure associated with the activities of response personnel. In many cases, response activities that impacted the soil structure were significantly more detrimental than the effect of the oil (Lindau et al 1999; Lin et al 1999; Pezeshki et al 2000). Avoiding physical damage to fragile marsh soils is critical to ensuring a speedy recovery of vegetation. Many experimental studies have found little difference between clean-up methods used and natural attenuation of oil in certain Gulf coast marshes (Lindau et al 2003; Lindau et al 1999; Lin et al 2002; Under the high temperatures and sunlight of a south Louisiana summer, natural attenuation of spilled oil can be quite rapid. Additionally, sandy shorelines with little wave action are particularly well attuned to cleaning oil if they have adequate nutrient availability, as our shoreline certainly does (Owens & Lee, 2003; Venosa & Zhu, 2003).This option could be used between other options and scheduled according to seasonal strategies.

Natural processes will be slower to remove the oil than other clean-up options and will increase the likelihood for its remobilization to adjacent aquatic areas. There is also an increased potential for long-term toxicity to organisms and vegetation depending on the nature of the oil spilled. In areas with low oxygen levels and few natural flushing mechanisms, such as intermediate freshwater marshes, pooled oil may be persistent for decades (Lin et al 1999; Michel et al 2009). In areas with large populations of wildlife, this may not be a prudent option.

The natural attenuation scenario may be the most appropriate choice for responding to oil spills where the amount of oil covering the surface of the marsh is relatively light, the product is highly weathered or not very toxic, and where very soft or otherwise easily-disturbed soils would be at an unacceptable risk for significant destabilization from a more interventionist approach.

Recommendations:

- Highly recommended in areas with soft organic soils where physical disturbance of soil is a primary concern
- Useful for light coverings or non-toxic types of oil
- Use as an opportunity to couple with research funds to evaluate response
- May not be plausible in areas with high concentrations of wildlife

3. Monitoring

Monitoring of short and long term impacts of the spill will be critical for restoration efforts in practice as well as in the event of legal conflicts with the responsible party. Even though it is typical for the potential responsible party to conduct their own studies to assess damages, it may behoove the trustees to perform “shadow studies” in the event of contradictory findings and any subsequent legal issues. Documentation (photos especially) and adherence to, or at least knowledge of, responsible party protocols for sampling are essential in a monitoring effort to ensure an adequate translation of loss of resources and services and subsequent restoration needs directly related to the oil spill.

4. Research Funding

These recommendations are intended to inform the large-scale cleanup of oiled wetlands that is likely to emerge from this incident. A small percentage of spill response money should be made available to research new or refine existing spill response technologies. This could be accomplished by reconstituting entities such as the Louisiana Oil Spill Research & Development Program (OSRADP), or using existing research & development entities. Much of our knowledge of the effectiveness and appropriateness of particular response options comes from past oil spill research funded by OSRADP and others. Given what may be wide-scale oil impacts to Louisiana’s wetlands, there will likely be the opportunity for testing novel techniques that could greatly inform response considerations to the inevitable next event.

5. References

Barataria-Terrebone National Estuary Program (2010). Chemical Dispersants. http://www.btnep.org/home.asp

Challenger, G., G. Sergy, & A. Graham. (2008). Vegetation response and sediemtn polycyclic aromatic hydrocarbon attenuation in a Carez marsh in Howe Sound, British Columbia, Canada following a spill of bunker C fuel oil. International Oil Spill Conference.

Dowty, R. A., G. P. Shaffer, M. W. Hester, G. W. Childers, F. M. Campo & M. C. Greene. (2001). Phytoremediation of small-scale oil spills in fresh marsh environments: a mesocosm simulation. Marine Environmental Research, 52, 195-211.

Fritz, D. E. (2003). In-situ burning of spilled oil in freshwater inland regions of the United States. Spill Science & Technology Bulletin, Vol 8, No 4, 331-335.

Henry, C. D. Helton, J. Michel & C. Woodle. (2008). Bayou Perot and the unusual situation of stranded oil adhered to mud flats. International Oil Spill Conference.

Hester, M. W. & I. A. Mendelssohn. (2000). Long-term recovery of a Louisiana brackish marsh plant community from oil-spill impact: vegetation response and mitigating effects of marsh surface elevation. Marine Environmental Research, 49. 233-254.

Holm, G. O. Jr., C. E. Sasser & P. J. Bergeron. (2003). Amelioration of freshwater, peat-based marshes after oil contamination: I. A field experiment; II. An historic spill site assessment. Louisiana State University, School of the Coast and Environment. Louisiana Applied and Educational Oil Spill Research and Development Program, OSRADP Technical Report Series, 28p.

Kirby, M. F. & R. J. Law. (2008). Oil spill treatment products approval: The UK approach and potential application to the Gulf region. Marine Pollution Bulletin, 56, 1243-1247.

Lindau, C. W., R. D. Delaune & I. Devai. (2003). Rate of turnover and attenuation of crude oil added to a Louisiana *Sagittaria lancifolia* freshwater marsh soil. Spill Science & Technology, Vol 8, Nos 5-6, 445-449.

Lindau, C. W., R. D. Delaune, A. Jugsujinda & E. Sajo. (1999). Response of Spartina alterniflora vegetation to oiling and burning of applied oil. Marine Pollution Bulletin, Vol 38, No 12, 1216-1220.

Lin, Q. & I. A. Mendelssohn. (2008). Evaluation of tolerance limits for restoration and phytoremediation with *Spartina alterniflora* in crude oil-contaminated coastal salt marshes. International Oil Spill Conference.

Lin, Q., I. A. Mendelssohn, K. Carney, N. P. Bryner & W. D. Walton. (2002). Salt marsh recovery and oil spill remediation after in-situ burning: effects of water depth and burn duration. Environmental Science Technology, 36, 576-581.

Lin, Q., I. A. Mendelssohn, C. B. Henry Dr., M. W. Hester & E. C. Webb. (1999). Effect of oil cleanup methods on ecological recovery and oil degradation of *Phragmites* marshes. International Oil Spill Conference, Paper ID # 250.

Louisiana Department of Environmental Quality, LA Dept of Natural Resources, LA, Dept of Wildlife & Fisheries, LA Oil Spill Coordinators Office, NOAA. (2007). The Louisiana Regional Restoration Planning Program Final Programmatic Environmental Impact Statement.

Michel, J., Z. Nixon, J. Dahlin, D. Betenbaugh, M. White, D. Burton & S. Turley. (2009). Recovery of interior brackish marshes seven years after the chalk point oil spill. Marine Pollution Bulletin, 58, 995-1006.

Nyman, J. A. (1999). Effect of crude oil and chemical additives on metabolic activity of mixed microbial populations in fresh marsh soils. Microbial Ecology, Vol 32, No 2, 152-162.

Owens, E. H. & K. Lee. (2003). Interaction of oil and mineral fines on shorelines: review and assessment. Marine Pollution Bulletin, 47, 397-405.

Page, C. A., R. L. Autenrieth, J. S. Bonner & T. McDonald. (2001). Behavior of chemically dispersed oil in a wetland environment. International Oil Spill Conference.

Pezeshki, S. R., M. W. Hester, Q. Lin & J. A. Nyman. (2000). The effects of oil spill and clean-up on dominant US Gulf coast marsh marcrophytes: a review. Environmental Pollution, 108, 129-139.

Smith, D. L. & C. E. Proffitt. (1999). The effects of crude oil and remediation burning on three clones of smooth cordgrass (Spartina alterniflora Loisel). Estuaries, Vol 22, No 3A, 616-623.

Venosa, A. D. & X. Zhu. (2003). Biodegradation of crude oil contaminating marine shorelines and freshwater wetlands. Spill Science & Technology Bulletin, Vol 8, No 2, 163-178.

Venosa, A. D., K. Lee, M. T. Suidan, S. Garcia-Blanco, S. Cobanli, M. Moteleb, J. R. Haines, G. Tremblay & M. Hazelwood. (2002). Bioremediation and biorestoration of a crude oil-contamincated freshwater wetland on the St. Lawrence River. Bioremediation Journal, Vol 6, No 3, 261-281.

Zengel, S. A. & J. Michel. (1996). Vegetation cutting as a clean-up method for salt and brackish marshes impacted by oil spills: a review and case history of the effects on plant recovery. Marine Pollution Bulletin, Vol 32, No 12, 876-885.

ive Species, Subsidence, Hydrological Modifications, Erosion, Ecotourism Development, Storm Surge, Overharvesting, Pollution, Toxicity, Aquaculture, Extinction, Comm

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